All water is chlorinated at any one of 10 points as it is drawn from the reservoir system, or as it leaves either of the two well fields. Rechlorination takes place at the Spring Street station. In 1973, a total of 3,099 mil gal was rechlorinated at this site. Secondary chlorination of the. distribution storage reservoirs also takes place. Calgon is added to the water at 11 points to reduce corrosion in the pipes. Fluoride is added at 12 points in the system, as required by State law.

TRANSMISSION AND DISTRIBUTION

The distribution system consists of 24 pumping stations, including those at the well sites, one storage reservoir, and 16 standpipes. The system is actually a number of small systems interconnected. The distribution reservoir and the standpipes have a total capacity of just over 3 mil gal. Table 62 identifies the distribution system's reservoir and standpipes and gives the capacity of each. There are 1,266 miles of pipe in the ground, ranging in size from 1 to 72 in.

COST ANALYSIS

Growth of consumer demand for water from 1964 through 1973 is illustrated in Figure 34. During the 10-year period there was only a slight increase in the amount of water used, and for the most part, that increase occurred with the acquisition of a small water utility in the 1966-67 time frame.

Using standard cost categories, data were collected and reported as shown in Tables 63, 64, and 65. Because a major portion of the operating budget was expended for labor, Table 66 was developed to examine labor costs for operation and maintenance activities. Because accurate man-hours were not available for the 5 years before 1969, that information is not part of this report.

Based on the records for 1969 through 1973, the cost for each man-hour increased 43%, and the amount of labor required to produce 1 mil gal increased by 32%. The increase in both these parameters reflects a rapid increase in the cost of producing water because there is a compounding relationship. For example, to produce 1 mil gal water in 1973 required 185.5 man-hours; in 1969, only 141.06 man-hours were required. In addition, a corresponding increase from $3.80 to $4.82/man-hour compounded the cost increase. The payroll and man-hours reflected in Table 66 include construction labor capitalized by the utility. The number of capitalized dollars, including both labor and materials, are identified in Tables 63, 64, and 65 and are removed from the total operating cost in subsequent areas of the report.

Table 67 summarizes operating and capital costs for the 10-year period of analysis. Table 68 computes capital and operating expenditure ratios. Operating expenses are those shown as the total of the values in Table 63, expenses incurred in the normal day-to-day operation of the system. The capital expenses are the total expenditures for providing major equipment items and facilities plus the interest charged on money borrowed for these purposes. A comparison of the operating expenses and the capital expenses

TABLE 62. NEW HAVEN WATER COMPANY DISTRIBUTION RESERVOIR AND STANDPIPES.

Location	Capacity (1,000 gallons)
Reservoir:	
Mill Rock*	8,660
Standpipes:	
Mill Rock	375
Burwell Hill	937
Burwell Hill	720
Shingle Hill*	720
Shingle Hill	2,000
Mount Carmel (2)	1,300
Summit Street	480
Rabbit Rock	1,000
Brushy Plains	1,000
High Rock	1,000
Naugatuck Avenue	800
Clark Hill	800
York Hill	2,500
Ford Street	2,100
Prospect Tank	2,500
North Branford	3,300
Total	30,192

* Open storage,

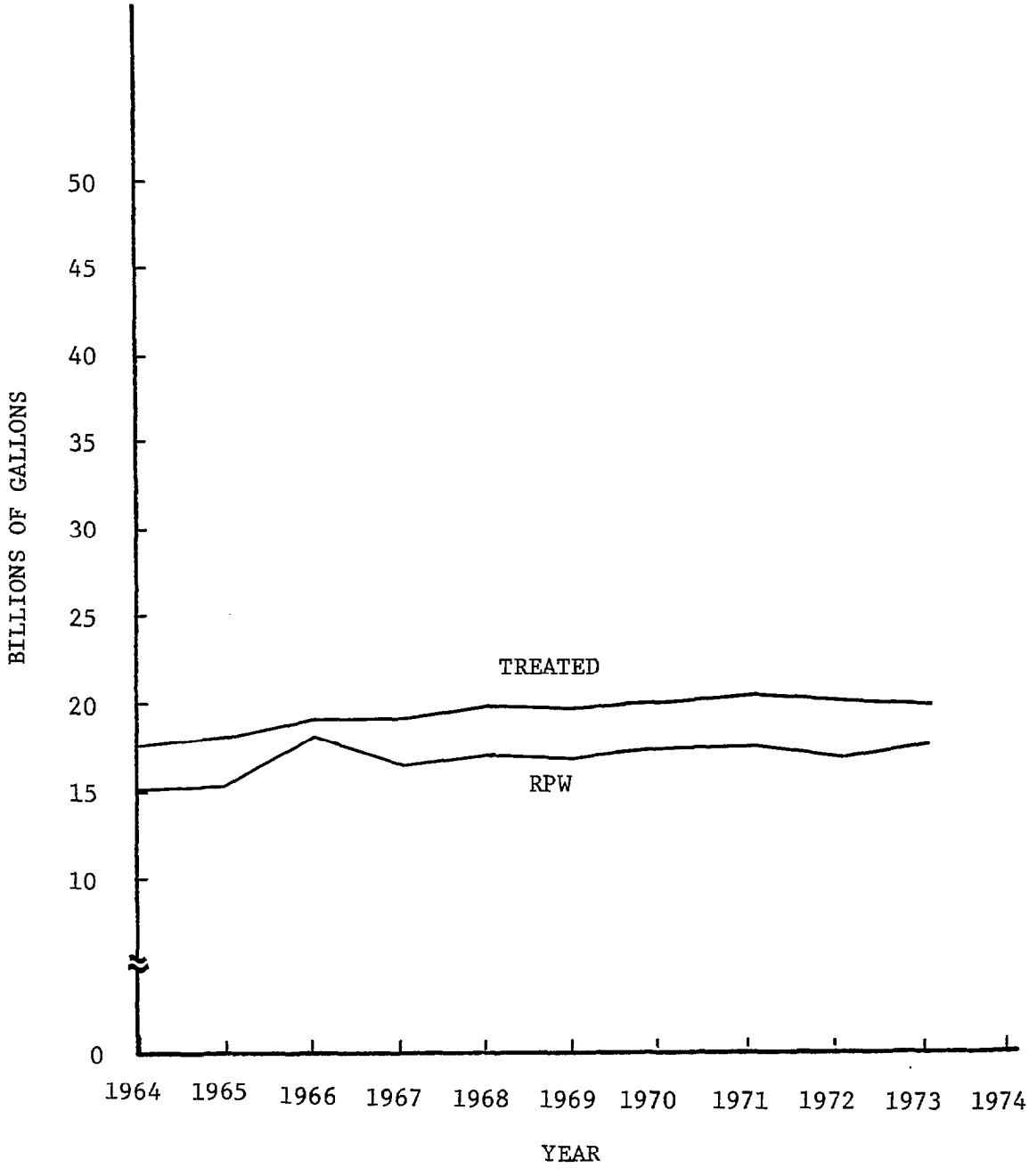

Figure 34. New Haven Water Company water flow: treated water versus RPW.

TABLE 63. NEW HAVEN WATER COMPANY ANNUAL OPERATING COSTS

Category	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
Support services:										
Administration	$ 575,812	$ 594,472	$ 657,124	$ 696,339	$ 786,883	$ 917,121	$1,042,840	$1,100,552	$1,168,414	$1,260,410
Acctg and collection	392,675	419,961	469,759	513,362	535,449	537,291	666,485	769,117	869,258	988,000
Other	-	(34,420)	(48,946)	(59,001)	(40,482)	(38,946)	(62,607)	(49,529)	(51,462)	(72,466)
Total	968,487	980,013	1,077,937	1,150,700	1,281,850	1,415,466	1,646,718	1,820,140	1,986,210	2,175,944
Acquisition:	368,518	346,286	351,387	343,381	373,210	416,149	387,544	407,834	437,367	459,699
Treatment:										
Supervision and labor	111,280	118,409	143,153	156,026	155,632	163,319	174,225	179,325	174,600	197,683
Chemicals	33,461	30,180	35,110	55,976	62,426	56,147	71,729	72,687	78,532	64,218
Maintenance	10,434	11,108	8,556	17,276	19,633	21,800	17,248	21,149	12,073	15,610
Other	-	7,342	8,016	7,855	8,697	8,941	8,050	10,572	10,810	14,411
Total treatment	155,175	167,039	194,835	237,133	246,388	250,207	271,252	283,733	276,015	291,922
Power and pumping:										
Supervision and labor	59,446	59,668	87,630	53,303	27,127	30,876	34,504	35,169	22,358	31,221
Maintenance	14,894	9,996	15,860	20,782	26,695	27,759	29,022	28,559	29,903	32,283
Power	109,047	120,946	141,310	128,472	124,867	135,997	142,187	159,400	181,979	211,242
Other	6,997	6,112	6,912	5,593	4,887	6,799	8,987	8,293	8,836	8,133
Total power and pumping	190,384	196,722	251,712	208,150	183,576	201,431	214,700	231,421	243,076	282,879
Transmission and distribution:										
Operations	343,714	333,716	352,545	383,994	393,372	452,988	486,155	529,472	501,822	519,990
Maintenance	153,810	147,720	188,762	199,450	143,383	182,793	229,070	213,585	330,730	265,005
Other	81,115	82,579	98,856	114,667	129,132	138,306	137,790	145,734	144,043	144,320
Total transmission & distribution	578,639	564,015	640,163	698,111	665,887	774,087	853,015	888,791	976,595	929,315
Total operating cost	2,261,203	2,254,075	2,516,034	2,637,475	2,750,911	3,057,340	3,373,229	3,631,919	3,919,263	4,139,759
Capitalized as construction	530,026 *	457,833	543,793	588,097	575,989	621,020	831,120	876,952	1,047,973	1,125,019

* Estimated

TABLE 64. NEW HAVEN WATER COMPANY OPERATING COSTS/($/MIL GAL RPW)

Category	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
Support services:										
Administration	$ 37.74	$ 38.14	$ 35.47	$ 42.21	$ 45.83	$ 53.56	$ 58.69	$ 61.38	$ 67.81	$ 71.15
Accounting and collection	25.74	26.94	25.36	31.12	31.19	31.38	37.51	42.89	50.45	55.78
Other	-	(2.21)	(2.64)	(3.58)	(2.36)	(2.27)	(3.52)	(2.76)	(2.99)	(4.09)
Total support services	63.48	62.87	58.19	69.75	74.66	82.67	92.68	101.51	115.27	122.84
Acquisition:	24.15	22.22	18.97	20.81	21.74	24.30	21.81	22.74	25.38	25.95
Treatment:										
Supervision and labor	7.29	7.60	7.73	9.46	9.07	9.54	9.80	10.00	10.13	11.16
Chemicals	2.19	1.94	1.90	3.39	3.64	3.28	4.04	4.05	4.56	3.63
Maintenance	0.68	0.71	0.46	1.05	1.14	1.27	0.97	1.18	0.70	0.88
Other	-	0.47	0.43	0.48	0.51	0.52	0.45	0.59	0.63	0.81
Total treatment	10.16	10.72	10.52	14.38	14.36	14.61	15.26	15.82	16.02	16.48
Power and pumping:										
Supervision and labor	3.90	3.83	4.73	3.23	1.58	1.80	1.94	1.96	1.30	1.76
Maintenance	0.98	0.64	0.86	1.26	1.55	1.62	1.63	1.59	1.74	1.82
Power	7.15	7.76	7.63	7.79	7.27	7.94	8.00	8.89	10.56	11.93
Other	0.46	0.39	0.37	0.34	0.28	0.40	0.51	0.46	0.51	0.46
Total power and pumping	12.49	12.62	13.59	12.62	10.69	11.76	12.08	12.90	14.11	15.97
Transmission and distribution:										
Operations	22.53	21.41	19.03	23.28	22.91	26.46	27.36	29.53	29.12	29.35
Maintenance	10.08	9.48	10.19	12.09	8.35	10.68	12.89	11.91	19.19	14.96
Other	5.32	5.30	5.34	6.95	7.52	8.08	7.75	8.13	8.36	8.15
Total transmission and distributi n	37.93	36.19	34.56	42.32	38.78	45.22	48.00	49.57	56.67	52.46
Total operating cost	148.21	144.62	135.83	159.88	160.22	178.56	189.83	202.54	227.45	233.70
Capitalized as construction	34.74 *	29.38	29.35	35.65	33.55	36.27	4 .77	48.91	60.82	63.51

* Estimate

TABLE 65. NEW HAVEN WATER COMPANY OPERATING COST CATEGORIES AS PERCENT OF TOTAL OPERATING COST

Category	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
Support services:										
Administration	25.46	26.37	26.11	26.40	28.60	30.00	30.92	30.31	29.81	30.45
Acctg and collection	17.37	18.63	18.67	19.46	19.47	17.57	19.76	21.18	22.18	23.87
Other	-	(1.53)	(1.94)	(2.24)	(1.47)	(1.27)	(1.85)	(1.36)	(1.31)	(1.75)
Total support services	42.83	43.47	42.84	43.62	46.60	46.30	48.83	50.13	50.68	52.57
Acquisition:	16.29	15.36	13.97	13.02	13.57	13.61	11.49	11.23	11.16	11.10
Treatment:										
Supervision and labor	4.92	5.26	5.69	5.92	5.66	5.34	5.16	4.94	4.45	4.78
Chemicals	1.40	1.34	1.40	2.12	2.27	1.84	2.13	2.00	2.00	1.55
Maintenance	0.46	0.49	0.34	0.66	0.71	0.71	0.51	0.58	0.31	0.38
Other	-	0.32	0.32	0.30	0.32	0.29	0.24	0.29	0.28	0.35
Total	6.84	7.41	7.75	9.00	8.96	8.19	8.04	7.81	7.04	7.06
Power and pumping										
Supervision and labor	2.63	2.65	3.48	2.02	0.99	1.01	1.02	0.97	0.57	0.75
Maintenance	0.66	0.44	0.63	0.79	0.97	0.91	0.86	0.79	0.77	0.78
Power	4.82	5.37	5.62	4.87	4.54	4.45	4.21	4.39	4.64	5.10
Other	0.31	0.27	0.27	0.21	0.17	0.22	0.27	0.23	0.22	0.20
Total power and pumping	8.42	8.73	10.00	7.89	6.67	6.59	6.36	6.38	6.20	6.83
Transmission and distribution:										
Operations	15.20	14.80	14.01	14.56	14.30	14.82	14.41	14.58	12.80	12.56
Maintenance	6.80	6.56	7.50	7.56	5.21	5.98	6.79	5.88	8.44	6.40
Other	3.59	3.66	3.93	4.35	4.69	4.53	4.08	4.01	3.68	3.49
Total transmission & distribution	25.59	25.02	25.44	26.47	24.20	25.33	25.28	24.47	24.92	22.45
Capitalized as construction	23.44	20.31	24.12	22.30	26.48	20.65	24.64	31.83	26.74	27.18

TABLE 66. NEW HAVEN WATER COMPANY LABOR COST ANALYSIS

Item	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
Total payroll * ($)	1,786,350	1,780,719	1,987,667	2,083,605	2,173,220	2,415,299	2,664,851	2,869,216	3,096,218	3,285,898
Total hours on payroll	---	---	---	---	---	715,520	690,560	713,440	686,400	682,240
RPW (mil gal)	15,256	15,585	18,526	16,498	17,168	17,122	17,769	17,931	17,231	17,714
Total payroll/mil gal RPW ($)	117.09	114.26	107.29	126.29	126.59	141.06	149.97	160.01	179.69	185.50
Total hours/mil gal RPW	---	---	---	---	---	41.79	38.86	39.79	39.84	38.51
Average cost/man-hour ($)	---	---	---	---	---	3.38	3.86	4.02	4.51	4.82
Payroll capitalized as construction ($)	N/A	322,163	378,405	423,806	392,573	397,271	558,420	557,629	712,524	771,979
Man-hours capitalized as construction	---	---	---	---	---	160,050	153,976	163,700	154,917	150,563

* Estimates as per 1973 distribution of salaries and wages (PUC pg. 313); to be revised during revisit.

TABLE 67. NEW HAVEN WATER COMPANY CAPITAL AND OPERATING COSTS

Item	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
Operating expense	1,731,177	1,796,190	1,710,280	2,049,378	2,174,923	2,386,319	2,542,108	2,754,967	2,871,290	2,014,740
Depreciation	675,890	738,431	738,431	892,758	956,164	1,072,890	1,158,462	1,236,515	1,357,659	1,503,812
Other										
Interest	443,386	498,536	498,536	561,053	642,527	692,177	976,765	1,358,734	1,679,893	2,067,270
Taxes	2,207,766	2,161,481	2,161,481	2,467,516	2,647,209	3,068,840	3,449,890	4,016,819	3,782,864	3,741,714
Total	5,028,219	5,194,638	5,108,728	5,970,705	6,420,823	7,220,226	8,127,225	9,367,035	9,691,706	10,327,536
Total cost/mil gal RPW	329.59	333.31	275.76	361.90	374.00	421.69	457.38	522.39	562.46	583.02

TABLE 68. NEW HAVEN WATER COMPANY CAPITAL VERSUS OPERATING EXPENSE RATIOS

Item	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
Operating expense ($)	3,938,943	3,958,671	3,871,761	4,516,894	4,822,132	5,455,159	5,991,998	6,770,927	6,654,154	6,756,454
Taxes ($)	2,207,766	2,161,481	2,161,481	2,467,516	2,647,209	3,068,840	3,449,890	4,016,819	3,782,864	3,741,714
Capital expense ($)	1,119,276	1,236,967	1,236,967	1,453,811	1,072,890	1,598,691	1,765,067	2,135,227	2,595,249	3,037,552
Interest ($)	443,386	498,536	498,536	561,053	642,527	692,177	976,765	1,358,734	1,679,893	2,067,270
Total cost ($)	5,058,219	5,195,638	5,108,728	5,970,705	5,898,022	7,053,850	7,575,065	8,906,154	9,249,403	9,794,006
Operating expense as % of total	77.87	76.19	75.79	75.65	81.80	77.34	77.25	76.03	71.94	68.99
Capital expense as % of total	22.13	23.81	24.21	24.35	18.20	22.66	22.75	23.97	28.06	31.01

as a percent of the total shows that in the New Haven Water Company, more expenses are associated with operations than with capital.

Over the 10-year period, the trend has been in the direction of capital rather than operations and reflects the continual investment made by the New Haven Water Company in improving its system. The shift was from approximately 80% operating versus 20% capital in 1964 to 69% operating versus 31% capital in 1973.

The system is relatively old, and the capital depreciated was expended when costs were significantly lower than at present. On the other hand, the operating expense is in current dollars. This ratio will significantly increase as major capital investments are made by the utility. For example, the company is starting to make major capital expenditures for treatment facilities. As these expenditures are made, the ratio of capital to operating expenses will increase significantly.

From a cost standpoint, New Haven Water Company is unusual in that the utility made major investments in large areas of land to control source water. Because of this, the company incurred liability for real estate taxes. Table 67 shows that a total of $3.7 million was paid for taxes in 1973. Most of this was real estate tax. This value divided by the billed consumption (17,714 mil gal) for 1973 shows that $211.23 was paid in taxes for each mil gal of water sold to consumers.

SYSTEM COSTS

Explanation of costs on a functional basis is only part of the total picture. Because the purpose of the utility is to deliver water to a consumer, it is important to present costs as they relate to the delivery of water to a demand point within the system. This section contains such an analysis.

Locations of the company's facilities are shown in Figure 35. To analyze the cost of water as it moves through acquisition to treatment to the customer, it is necessary to identify the capital and operating cost of each system component. Figure 36 is a schematic diagram of Figure 35 and shows the operating and capital costs for each of the system's major facilities. A linear assumption is made to allow unit cost/($/mil gal) to be added as water moves from one system component to another. Transmission distances are relatively short because water is added at many points within the system. Little variation exists in the cost of providing water to any specific point in the service area.

The terrain served is relatively level, reservoirs are generally located on higher ground, and the water is gravity fed into the distribution system. The exception to this occurs in the well fields and the Lake Whitney reservoir, where the water is lifted into the system. Once the water is in the distribution system, it is pumped to maintain pressure and to lift the water into the standpipes. Generally speaking, because the water enters the distribution system and is pumped at so many various points, it is normally

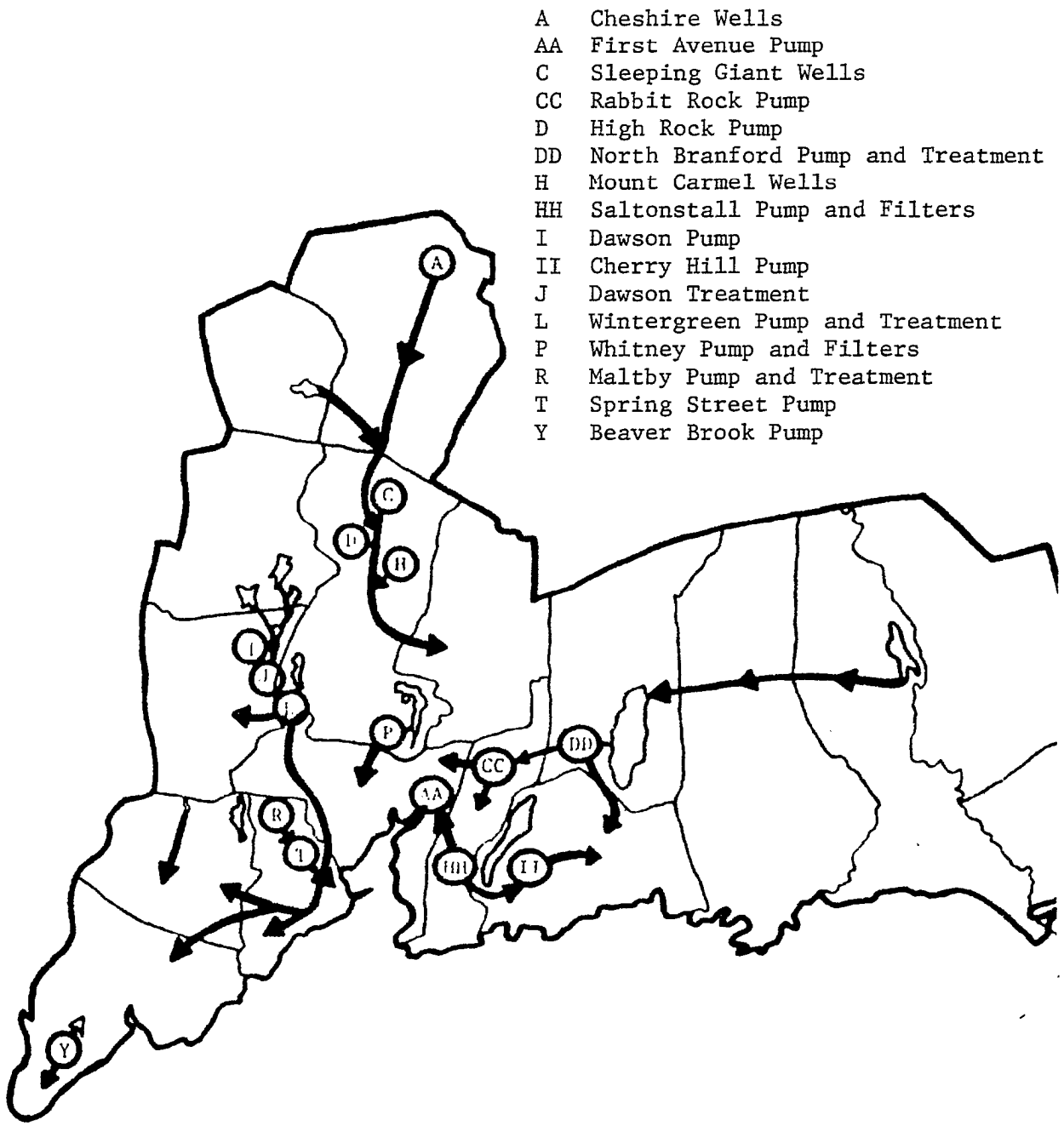

Figure 35. New Haven Water Company location of facilities and general direction of water flow in the retail service areas.

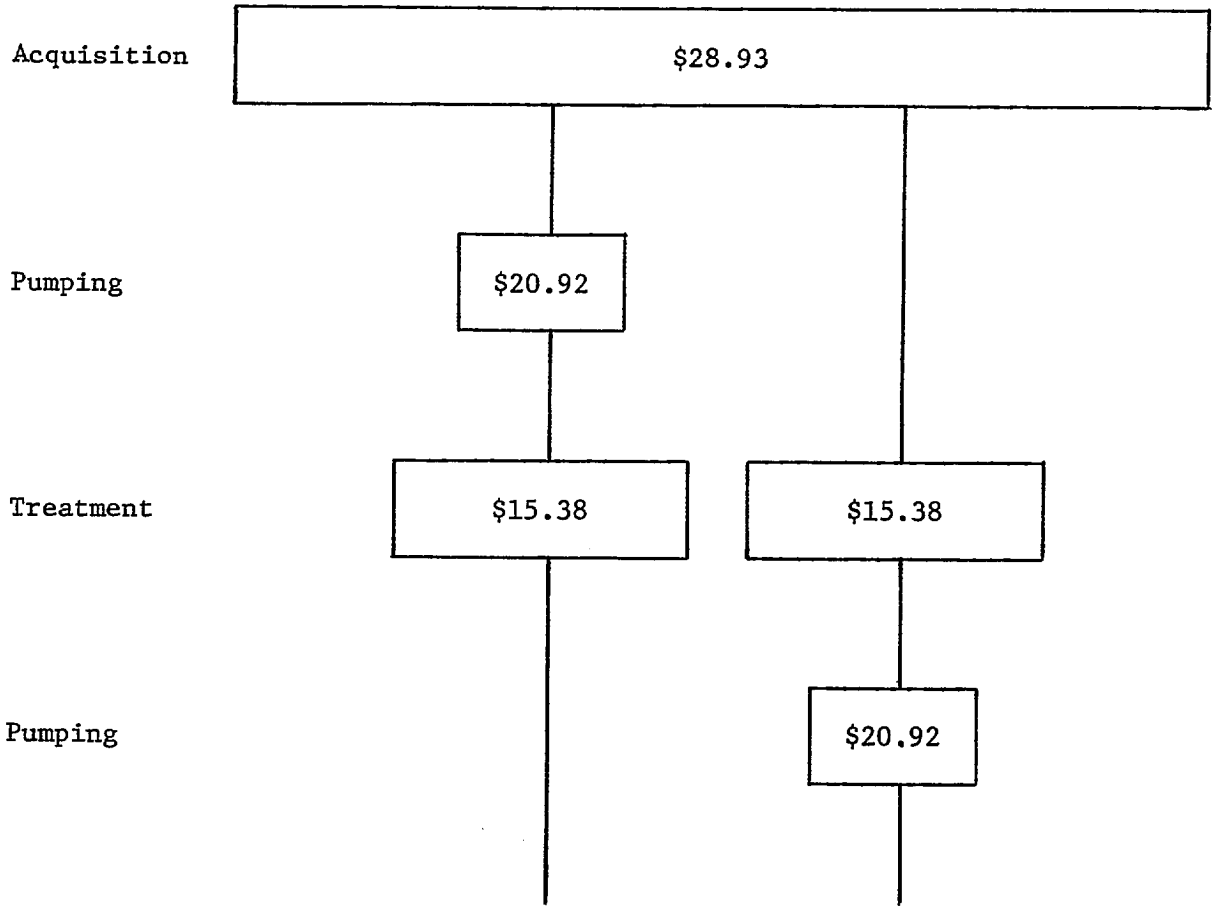

Figure 36. New Haven Water Company allocation of capital and operating expenses to water system components ($/mil gal RPW).

delivered to the consumer without being repumped. Since the cost for repumping is small, it is included in the cost of the initial pumping.

Figure 36 shows the costs associated with acquiring, treating, and pumping water within the system. As discussed, water is not transported over great distances, and the schematic presentation is simple. The only significant variation in the system is whether the pumping occurs before or after the chlorine and fluoride are added. This does not affect the cost.

Available data allowed a breakout of capital and operating costs only to the general categories of the operations. For example, breakout cost on each individual reservoir or well system was not available, and it was necessary to accumulate all the costs related to the reservoirs and divide the total by the RPW to arrive at the total acquisition cost of $28.93/mil gal. Using the same procedure, the pumping cost is $20.92/mil gal, and the treatment cost is $15.38/mil gal. The sum of these costs is $65.23, which represents the incremental cost for providing water to any distribution point in the system. Added to this expense are the costs for distribution, interest, and support services. Distribution cost is calculated on the assumption that the cost/mil gal is constant throughout the system; therefore, total capital and operating costs for distribution are divided by the number of gallons of revenue-producing water for the year under consideration. The same approach is taken for taxes ($211.23/mil gal), as described earlier. Adding the cumulative sums gives an average cost for delivery of water to the consumer of $583.01/mil gal. These data are outlined as follows:

Costs:	
Incremental	$65.23
Distribution	86.45
Interest	116.70
Support services	103.40
Taxes	211.23
Total	583.01
Metered consumption (mil gal)	17,714
Revenue ($)	10,327,439

Once these calculations are made, costs versus charges can be examined. Tables 69 through 73 summarize charges for typical monthly water consumption in New Haven. Table 74 gives RPW for the 10 largest customers of the New Haven Water Company.

Converting the units used to mil gal and dividing that into the amount billed makes it possible to examine the amount actually paid/mil gal, as shown in the last column of Table 73.

Because water is delivered to all users within the service area at approximately the same cost, it is possible to compare the average cost of delivering water with the amount paid by the major users. This comparison shows that major users are not paying the cost of producing and delivering water.

TABLE 69. NEW HAVEN WATER COMPANY QUARTERLY RATE SCHEDULE*

Units used (cu ft)	Cost/100 cu ft
First 500 or less +	---
Next 29,500	$0.63
Next 70,000	.49
Next 900,000	.37
Over 1,000,000	

* For all meter sizes.
\+ See Table 70.

TABLE 70. NEW HAVEN WATER COMPANY QUARTERLY RATE SCHEDULE

Meter size (in.)	Charge for 1st 500 cu ft or less	Minimum charge	Allowance for minimum charge (cu ft)
5/8 + 3/4	$10.38	$12.38	500
1	12.46	17.50	1,300
1½	16.61	29.21	2,500
2	20.66	42.71	4,000
3	33.03	77.13	7,500
4	49.49	125.09	12,500
6	90.59	244.94	25,000
8	131.25	378.35	42,500
10	172.68	517.78	62,500
Privately owned	3.15	3.15	500

TABLE 71. NEW HAVEN WATER COMPANY SEASON RATE SCHEDULE*

Units used (cu ft)	Cost/100 cu ft
First 1,300 or less+	---
Next 68,700	$0.63
Next 163,300	.49
Over 233,500	.37

* For all meter sizes.
\+ See Table 72.

TABLE 72. NEW HAVEN WATER COMPANY SEASON RATE SCHEDULE

Meter size (in.)	Charge for 1st 1,300 cu ft or less	Minimum charge	Allowance for minimum charge (cu ft)
5/8 + 3/4	$46.53	$46.53	1,300
1	51.73	63.70	3,200
1½	62.11	93.61	6,300
2	72.23	127.04	10,000
3	103.16	213.41	18,800
4	144.31	333.31	31,300

TABLE 73. NEW HAVEN WATER COMPANY QUARTERLY RATE CHARGE ANALYSIS

Units used (cu ft)	Gallons used	Meter size (in.)	Charge
13.4	10,000	5/8	$15.67
5,000	3,740,260	4	2,058.34
100,000	74,805,200	10	29,681.53
150,000	112,207,800	10	43,931.53

TABLE 74. RPW FOR NEW HAVEN WATER COMPANY'S TEN MAJOR USERS

Major user	High or low month	Month	Units used (mil gal)	Amount billed	Unit charge ($/mil gal)	cost zone
Olin Corporation	High	Oct	120.0	$32,105.90	$267.62	1
	Low	Mar	80.6	21,724.14	269.63	
Yale University	High	*	296.5	101,036.89	340.72	1
	Low		249.6	88,694.19	355.29	
Simkins Industry	High	Sep	42.6	11,684.34	274.40	1
	Low	Jul	24.3	6,850.07	282.34	
United Illinois Co.	High	Sep	31.3	8,697.56	278.21	1
	Low	Mar	17.8	5,163.13	289.85	
Armstrong	High	Apr	30.1	8,429.12	279.98	1
	Low	May	17.8	5,182.43	290.82	
Federal Paper	High	Feb	22.8	6,479.14	284.42	1
	Low	Mar	10.7	4,226.16	396.32	
Schick	High	Sep	22.9	6,490.16	283.44	1
	Low	Mar	11.3	3,446.57	304.79	
Connecticut Light and Power	High	Apr	23.8	7,196.78	301.94	1
	Low	Mar	12.1	4,116.20	340.35	
Upjohn	High	Feb	20.1	6,238.03	309.89	1
	Low	Mar	12.8	4,313.99	335.98	
Penn Central	High	Jan	11.8	3,668.15	309.94	1
	Low	Nov	6.5	2,242.10	342.83	

* Billed quarterly.

The average costs/mil gal for all water supplied during the most recent year studied are given as follows:

	$/mil gal
Support services	$113
Acquisition	29
Treatment	15
Distribution	107
Interest	117
Taxes	179
Total	560

SECTION 10

FAIRFAX COUNTY WATER AUTHORITY

The Fairfax County Water Authority, headquartered in Annandale, Virginia, was created under the Virginia Water and Sewage Authority Act of 1950 and chartered by the State Corporation Commission on September 26, 1957, for the purpose of acquiring, constructing, operating, and maintaining an integrated water system to supply and distribute water to Fairfax County. The charter was amended in 1959 to add the provision for sewer systems and sewage disposal systems located within Fairfax County and partly within and without the county.

The Authority is a public body politic incorporate deemed to be an instrumentality exercising public and essential governmental functions to provide for the public health and welfare. The Authority is empowered to: (1) acquire, construct, operate, and maintain water supply systems; (2) finance its programs through the issuance of revenue bonds without obtaining referendum approval; and (3) fix and prescribe rates, fees, and charges for the service rendered. It cannot levy any taxes or assessments, nor do the obligations of the Authority become obligations of Fairfax County.

Since 1959, the Authority has acquired 15 water companies, consisting of 22 separate water systems. The Alexandria Water Company, acquired in 1967, served 70% of the customers gained through the acquisition of 15 companies.

The Fairfax County Water Authority serves approximately two-thirds .of the population (364,000) in Fairfax County and small areas in adjoining counties. The population is relatively stable, and little construction activity is taking place in the service area. System facts are given in Table 75.

WATER SUPPLY SERVICE AREA

The retail service area shown in Figure 37 encompasses approximately 400 sq miles in Fairfax County. Water is supplied to some areas lying partly outside the county, such as Dulles Airport. In addition to serving county residents, the Authority wholesales treated water to places such as Alexandria, Prince William Water Company, and other areas located in or near Fairfax County.

The service area is relatively level, with elevations varying between 0 to 510 ft above sea level. The treatment plant is located at 260 ft above sea level, or approximately in the middle of the elevation range.

TABLE 75. FAIRFAX COUNTY WATER AUTHORITY, BASIC FACTS (1974)

Item	Amount
Population:	
SMSA	
County	552,000
Retail service area	364,000
Area of retail service area (sq miles)	400
Recognized customer classes (no. of metered accounts):	
Single family	71,977
Townhouses	8,650
Apartments	1,188
Commercial and industrial	2,635
Municipal-institutional	515
Flat Rate (no. of accounts)	None
Percent metered	100
Purchased water (mil gal treated)	1,627
Source water	97% Surface, 3% Wells
Pipe in system (miles)	1,256
Elevation of treatment plant (ft above mean sea level)	260
Elevation of service area (min-max ft)	0 - 510
Revenue-producing water (mil gal)	21,411
Treated water (pumpage from treatment plants + treated purchased water, mil gal)	19,096
Maximum day/maximum hour (MGD)	91/N.A.

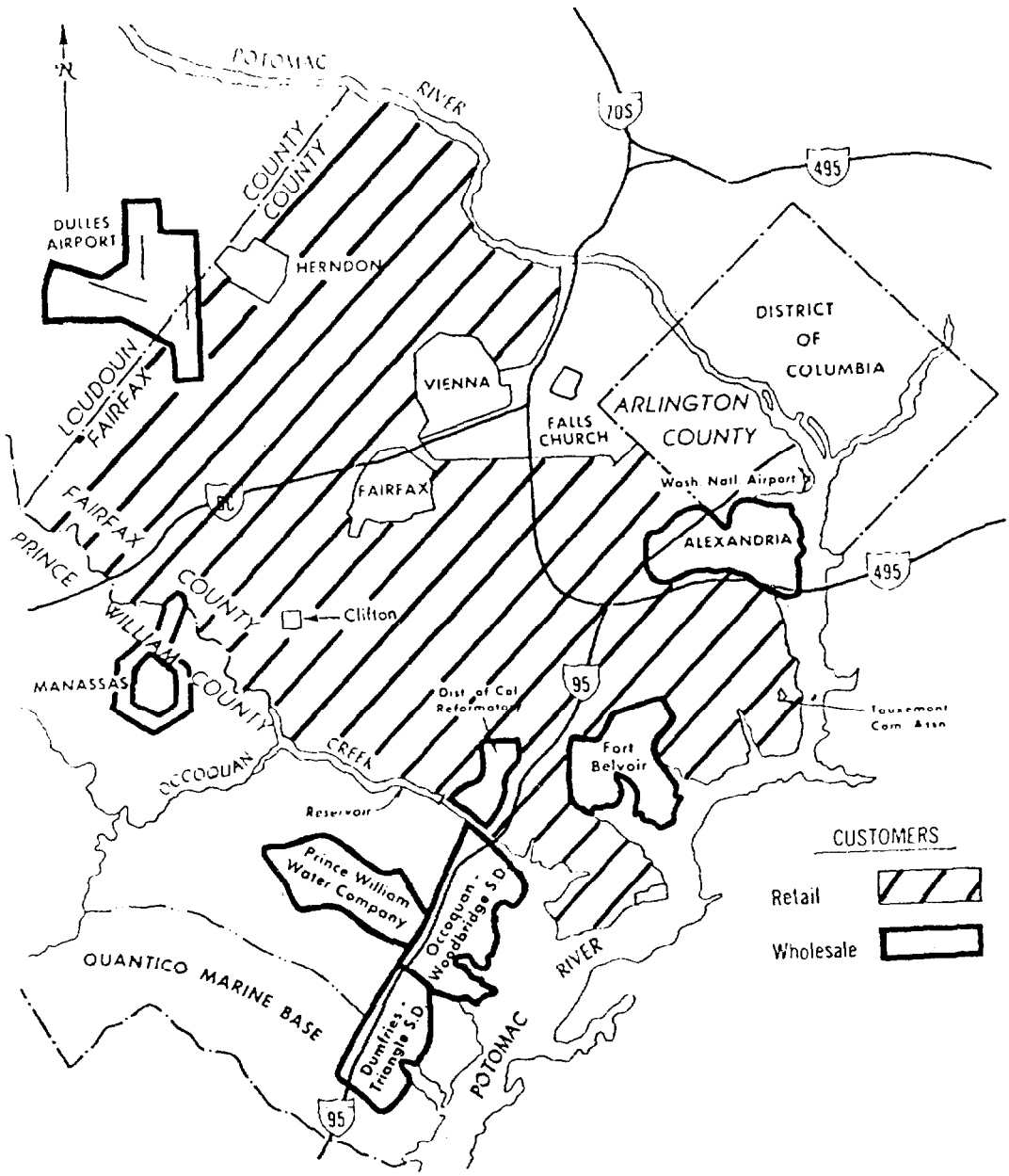

Figure 37. Fairfax County Water Authority location map and service areas.

This area is not expected to expand significantly in size unless an additional water system (such as the City of Fairfax) is acquired; however, the population is projected to increase the water demands at a rate of 3% to 4%/year through the year 1985.

ORGANIZATION

The Authority is administered by a board of five members appointed by the County Board of Supervisors for staggered terms of 3 years each. Officers are elected by the members for a term of 1 year. Operations are accomplished by a director who reports to the five-member board.

As shown in Figure 38, the director has four divisions reporting to him: (1) Engineering and Construction, responsible for designing and building facilities; (2) Finance, principally responsible for acquiring funds to support the operations; (3) Operations and Maintenance, responsible for accomplishing the production work and maintaining the equipment; and (4) General Services, responsible for performing the support activities necessary to the operation of the utility.

Although the charter includes the right to provide sewage service, none is provided at present time and therefore it was not necessary to separate costs for water and sewage functions.

ACQUISITION

Raw water for the Fairfax County Water Authority comes from both surface and ground sources. Approximately 97% of the water used is surface water, and 3% is groundwater.

The principal source of water is the Occoquan River, located in Fairfax, Fauquier, Loudon, and Prince William Counties with an impounded watershed of approximately 570 sq miles. Two dams constructed near Occoquan impound the river for water supply. The lower dam, constructed in 1950, impounds a relatively small reservoir containing about 55 mil gal, and the upper dam, constructed approximately 3,000 ft upstream from the lower dam in 1957, impounds a reservoir containing about 9.8 billion gallons. As presently developed, the impounding water supply has a dependable yield of approximately 65 MGD, even under the most severe drought conditions of record. Usually during the months of November through April, hydroelectric generating facilities utilize surplus stream flow to generate the power for pumping and treating water.

Supplementary [illegible]es of water include 30 wells and the purchase of water from Fort Belvoir an[illegible]che cities of Fairfax and Falls Church. Provisions in the design and construction of the larger dam will permit 5-ft increase in height, which will increase storage by about 3 billion gallons. This additional storage will increase the dependable yield to approximately 84 MGD. Easements have been obtained for flooding the additional acerage along the shoreline when the height of the dam is increased.

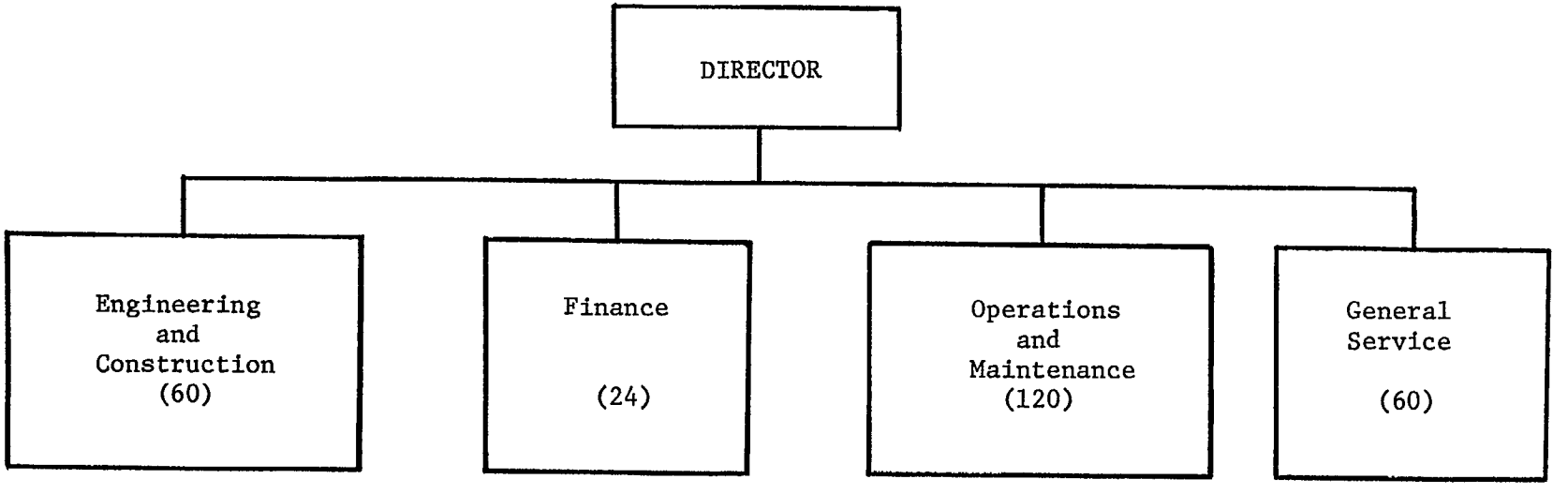

Figure 38. Fairfax County Water Authority organizational chart.

TREATMENT

Water treatment is provided in two interconnecting plants constructed in stages during the period 1950 to 1973. The combined maximum capicity of these facilities is 99.6 MGD.

The principal chemicals used in the treatment process include: (1) chlorine for disinfection, manganese and iron removal as well as taste and odor control, (2) activated carbon for taste and odor control, (3) alum to assist in the coagulation and settling of suspended materials, (4) lime to increase alkalinity for optimum coagulation and to inhibit pipe corrosion, (5) potassium permanganate for magnesium removal, (6) sodium bisulfite as a dechlorinating agent, and (7) fluoride for retardation of tooth decay. Four filtered water reservoirs containing about 4.8 mil gal are located at the treatment plant. Figure 39 presents a schematic diagram of the treatment plant.

TRANSMISSION AND DISTRIBUTION

The transmission and distribution system of the Fairfax County Water Authority consists of approximately 1,256 miles of mains varying in diameter from 2 to 30 in. Water is delivered into the transmission and distribution system by 18 pumping units providing a maximum capacity of 100 MGD. Operating pressures are maintained throughout the service area by 22 booster pumping stations, with capacities ranging from 0.13 to 41.0 MGD.

A total of 19 mil gal water is stored in 44 reservoirs located within the service area principally, as follows: 9 mil gal in three standpipes near Annandale, 5 mil gal in two standpipes at Gum Springs, 2 mil gal in two standpipes at Penderwood, and 1 mil gal in an elevated storage tank at the Fairfax County Hospital.

The distribution system is interconnected at 62 locations with 12 other water systems in northern Virginia. Five of these systems have independent water supply sources, and seven are dependent on the Authority for their water supply. The water storage facilities of the Fairfax County Water Authority, their number, and capacity are listed in Table 76.

In addition to its principal system, the Authority owns and operates seven independent well systems providing service to about 300 customers in communities distant from the principal system.

COST ANALYSIS

The rapid growth in RPW from 1964 through 1973 (Figure 40) reflects the acquisition of utilities rather than new customers within the service area. The acquisition of the Fairfax Water Company in 1967 more than doubled the amount of water sold by the Authority.

Using the standard cost categories, data were collected and reported as shown in Tables 77, 78, and 79. There are no data breakouts below the level of the total before 1968; the operations changed so radically in 1967 with

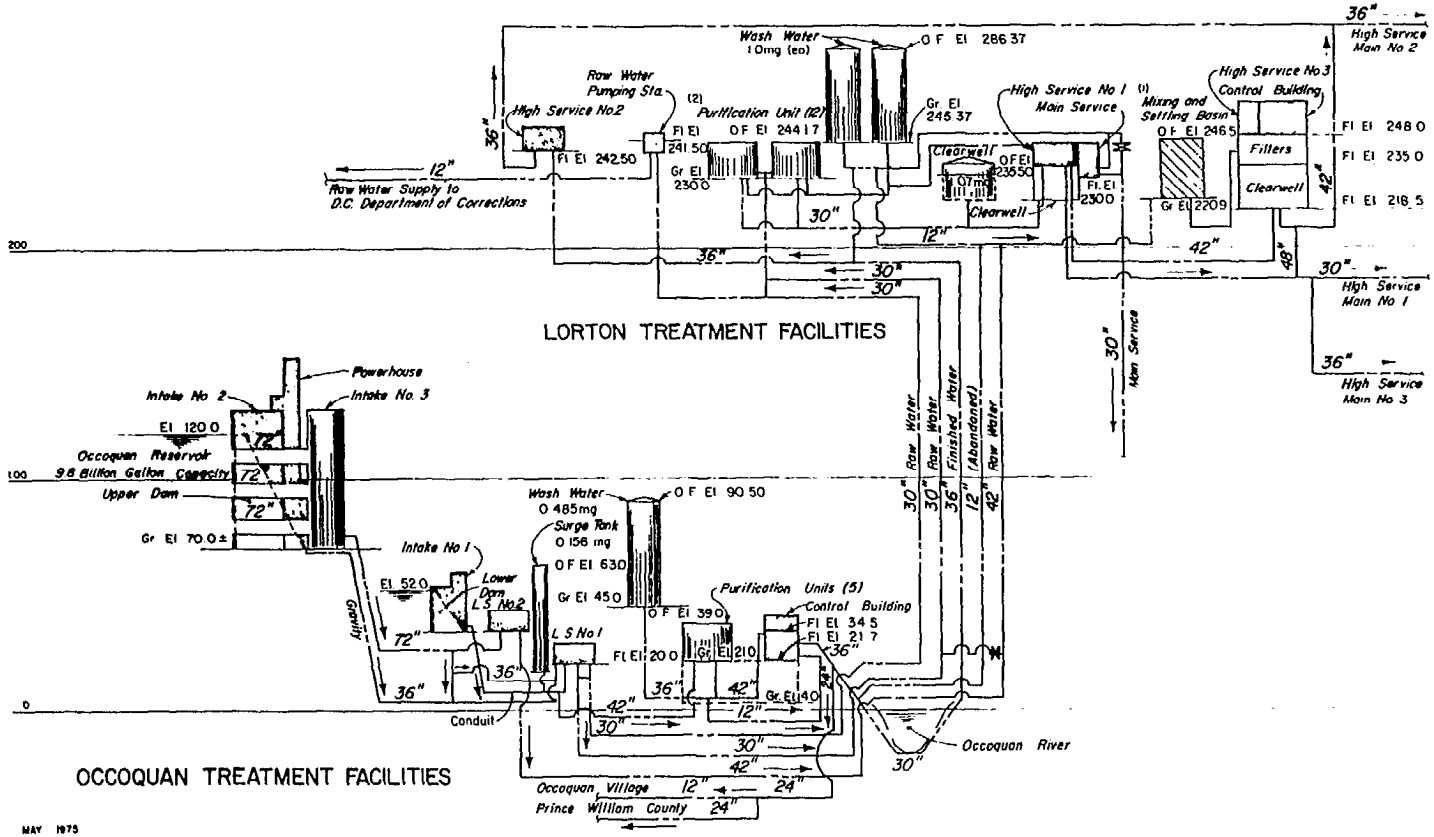

Figure 39. Fairfax County Water Authority schematic diagram of treatment facilities.

TABLE 76. FAIRFAX COUNTY WATER AUTHORITY STORAGE FACILITIES

Facility	Standpipes	
	Number	Total capacity (mil gal)
Annandale	3	9
Gum Springs	2	5
Penderwood	2	2
Fairfax County Hospital (elevated tank)	1	1
40 Locations (miscellaneous storage)	---	2
Total storage capacity		19

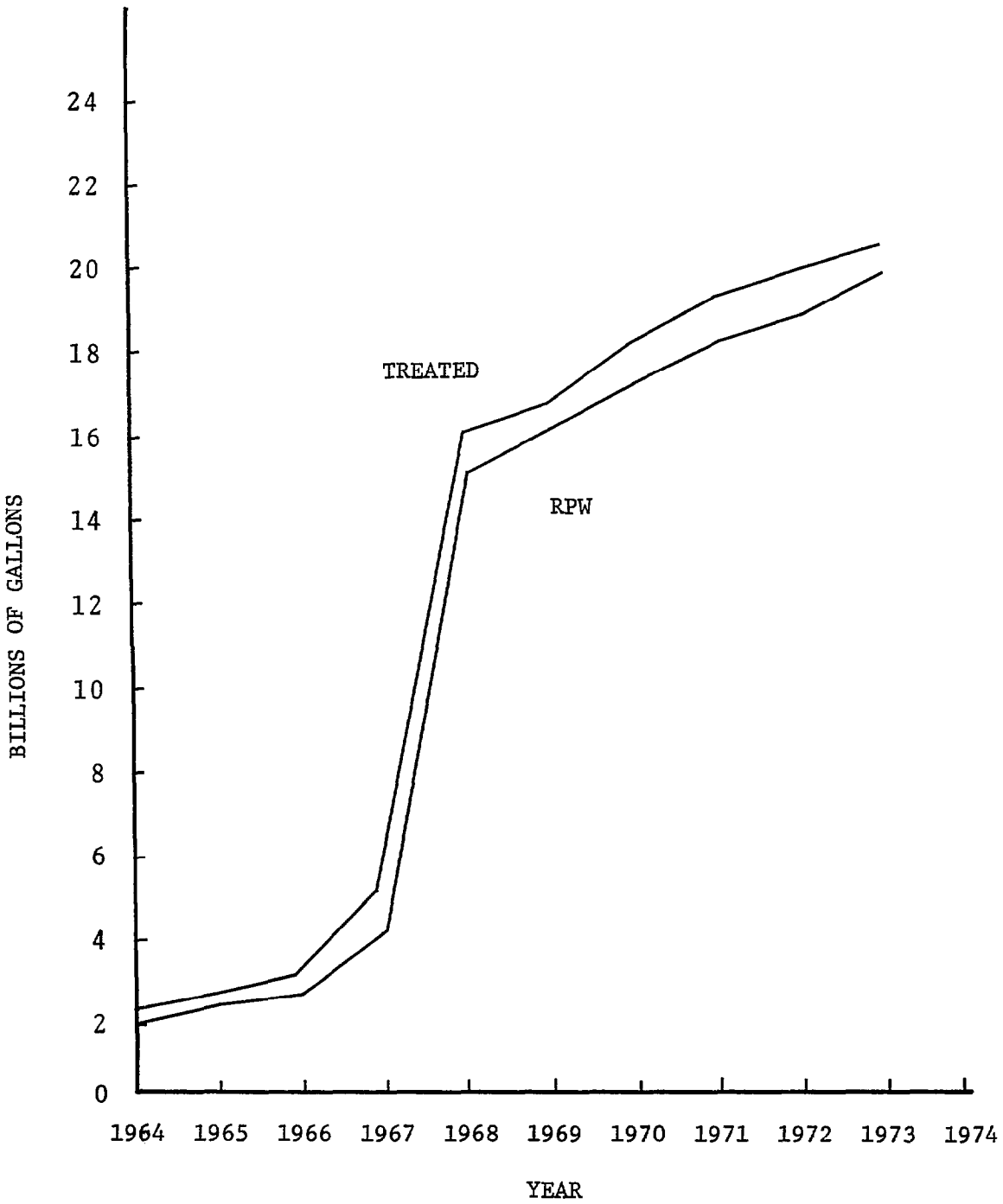

Figure 40. Fairfax County Water Authority water flow: treated water versus RPW.

TABLE 77. FAIRFAX COUNTY WATER AUTHORITY ANNUAL OPERATING COSTS*

Category	1964+	1965	1966	1967	1968	1969	1970	1971	1972	1973‡
Support services:										
Administration	---	---	---	---	$ 108,576	$ 79,520	$ 91,124	$ 115,267	$ 120,524	$ 163,791
Accounting and collection	---	---	---	---	256,520	341,445	392,215	471,967	491,998	719,886
Other	---	---	---	---	308,194	579,233	769,956	645,210	793,847	665,136
Total support services	---	---	---	---	673,290	1,000,198	1,253,295	1,232,444	1,406,369	1,548,813
Acquisition:										
Personnel	---	---	---	---	16,928	23,410	21,188	25,525	24,633	---
Water purchased	---	---	---	---	128,490	179,948	226,970	259,171	215,705	341,832
Maintenance	---	---	---	---	4,543	2,378	1,588	4,178	3,010	---
Other	---	---	---	---	277	33	1	78	---	---
Total acquisition	---	---	---	---	150,238	205,769	249,747	288,952	243,348	387,470
Treatment:										
Personnel	---	---	---	---	168,224	179,716	223,696	256,252	279,924	---
Chemicals	---	---	---	---	249,153	350,688	312,576	259,208	269,633	325,340
Other	---	---	---	---	44,434	33,660	38,210	39,105	36,460	---
Total treatment	---	---	---	---	461,811	564,064	574,482	554,565	586,017	584,170
Power and pumping:										
Personnel	---	---	---	---	84,738	112,739	108,212	149,526	185,058	---
Power	---	---	---	---	225,284	248,880	279,512	286,918	309,795	350,195
Maintenance	---	---	---	---	14,180	17,925	15,776	15,979	21,000	---
Other	---	---	---	---	5,642	4,364	5,099	10,153	12,125	---
Total pumping	---	---	---	---	329,844	383,908	408,599	462,576	527,978	526,275
Transmission and distribution:										
Personnel	---	---	---	---	199,573	225,555	259,511	307,050	408,495	---
Maintenance	---	---	---	---	68,809	48,605	97,042	123,908	107,112	---
Other	---	---	---	---	433,567	462,760	386,347	486,943	658,382	---
Total trans. and distribution	---	---	---	---	701,949	736,920	742,900	917,901	1,173,989	1,385,546
Total operating cost	$707,901	$834,487	$1,096,406	$1,345,317	2,317,132	2,890,859	3,229,023	3,456,438	3,937,701	4,432,274

* As per total current expenses from respective annual reports.

+ Except for totals, 1964-67 data are excluded because they are not comparable to 1968-73 data, the period after acquisition of the Alexandria Waterworks.

‡ Cost figures for certain categories not complete.

TABLE 78. FAIRFAX COUNTY WATER AUTHORITY UNIT OPERATING COSTS ($/mil gal RPW)

Category	1964*	1965	1966	1967	1968	1969	1970	1971	1972	1973
Support services:										
Administration	---	---	---	---	$ 7.30	$ 4.96	$ 5.34	$ 6.55	$ 6.51	$ 8.52
Accounting and collection	---	---	---	---	17.26	21.31	23.01	26.82	26.59	37.43
Other	---	---	---	---	20.73	36.16	45.16	36.66	42.90	34.58
Total support services	---	---	---	---	45.29	62.43	73.51	70.03	76.00	80.53
Acquisition:										
Personnel	---	---	---	---	1.14	1.46	1.24	1.45	1.33	---+
Water purchased	---	---	---	---	8.64	11.23	13.31	14.73	11.66	17.77
Maintenance	---	---	---	---	.31	.15	.09	.24	.16	---
Other	---	---	---	---	.02	---	---	---	---	---
Total acquisition	---	---	---	---	10.11	12.84	14.64	16.42	13.15	20.15
Treatment										
Personnel	---	---	---	---	11.32	11.22	13.12	14.56	15.13	---
Chemicals	---	---	---	---	16.67	21.89	18.33	14.73	14.57	16.92
Other	---	---	---	---	2.99	2.10	2.24	2.22	1.97	---
Total treatment	---	---	---	---	31.07	35.21	33.69	31.51	31.67	30.37
Power and pumping										
Personnel	---	---	---	---	5.70	7.04	6.35	8.50	10.00	---
Power	---	---	---	---	15.15	15.54	16.39	16.30	16.74	18.21
Maintenance	---	---	---	---	.95	1.12	.93	.91	1.13	---
Other	---	---	---	---	.38	.27	.30	.58	.66	---
Total power and pumping	---	---	---	---	22.18	23.97	23.97	26.29	28.53	27.36
Transmission and distribution:										
Personnel	---	---	---	---	13.42	14.08	15.22	17.45	22.08	---
Maintenance	---	---	---	---	4.63	3.03	5.69	7.04	5.79	---
Other	---	---	---	---	29.17	28.89	22.66	27.67	35.58	---
Total Transmission and distribution	---	---	---	---	47.22	46.00	43.57	52.16	63.45	72.05
Total unit operating cost	$397.92	$402.22	$451.57	$340.59	155.87	180.45	189.38	196.41	212.80	230.46

* Except for totals, 1964-67 data are excluded because they are not comparable to 1968-73 data, the period after acquisition of the Alexandria Waterworks.

+ Insufficient information.

TABLE 79. FAIRFAX COUNTY WATER AUTHORITY OPERATING COST CATEGORIES AS PERCENT OF TOTAL OPERATING COST

Category *	1968	1969	1970	1971	1972	1973
Support Services:						
Administration	4.68	2.75	2.82	3.33	3.06	3.70
Accounting and collection	11.07	11.81	12.15	13.66	12.50	16.24
Other	13.31	20.04	23.85	18.67	20.15	15.00
Total support services	29.06	34.60	38.82	35.66	35.71	34.94
Acquisition:						
Personnel	0.73	0.81	0.65	0.74	0.63	---+
Water purchased	5.54	6.22	7.03	7.50	5.48	7.71
Maintenance	0.20	0.08	0.05	0.12	0.08	---
Other	0.01	---	---	---	---	---
Total acquisition	6.48	7.11	7.73	8.36	6.19	8.74
Treatment:						
Personnel	7.26	6.22	6.93	7.41	7.11	---
Chemicals	10.75	12.13	9.68	7.50	6.85	7.34
Other	1.92	1.16	1.18	1.13	0.93	---
Total treatment	19.93	19.51	17.79	16.04	14.89	13.18
Power and pumping:						
Personnel	3.66	3.90	3.35	4.33	4.70	---
Power	9.72	8.61	8.65	8.30	7.87	7.90
Maintenance	0.61	0.62	0.49	0.46	0.53	---
Other	0.24	0.15	0.16	0.30	0.31	---
Total power and pumping	14.23	13.28	12.65	13.39	13.41	11.87
Transmission and distribution:						
Personnel	8.61	7.80	8.04	8.88	10.38	---
Maintenance	2.97	1.68	3.00	3.58	2.71	---
Other	18.72	16.01	11.97	14.09	16.71	---
Total transmission and distribution	30.30	25.49	23.01	26.55	29.80	31.27
Total operating expense	100.00	100.00	100.00	100.00	100.00	100.00

* Excludes 1964-67 data because they are not comparable to 1968-73 data, the period after acquisition of the Alexandria Waterworks.

+ Insufficient information.

the acquisition of the Alexandria Waterworks that any breakout on a comparative basis is not meaningful. Even the 1968 data are somewhat questionable, because the Authority was still suffering the impact of the major change.

The effect of selling more water is readily seen in Table 78. During the preceding years, the unit operating cost was in the neighborhood of $400/mil gal. In 1968, with the larger amount of water sold, the operating cost decreased sharply to $155/mil gal. From that point on, a steady and rather consistent increase on a $/mil gal basis has occurred each year.

The relative increase in cost for support services is significantly higher than for other areas of the operating budget. Table 80 examines labor costs associated with the operation and maintenance activities of the utility. The cost/man-hour from 1968 through 1973 increased by 54%, and the total payroll hours required to produce 1 mil gal of RPW increased by 14 percent. Because more man-hours are required and because the cost/man-hour is increasing, total cost for support services is compounding.

Operating and capital costs are summarized in Table 81 for the full 10-year period. As indicated by the capital and interest figures, a major change occurred between 1967 and 1968, when the major capital investment was made.

Capital and operating expense ratios are computed in Table 82. The operating expenses shown are the costs incurred in the normal day-to-day operation of the system. The capital expenses are the total expenses for providing major equipment items and facilities plus the interest charged on money borrowed for that purpose.

A comparison of the operating and capital expenses as a percent of the total cost shows that in the Fairfax County Water Authority, more expenses are associated with capital than with operations. This is contrary to the condition found in most of the utilities monitored and is surely influenced by the fact that the major capital expenditure of Fairfax County is more recent than in most of the systems. Again, a significant shift can be seen between 1967 and 1968, when the ratio of operating to capital expense decreased from 46 percent to 27 percent. The ratio is gradually shifting more toward the operating area; by 1973 it reached 44% because of rapid increases in operating costs, especially in the labor area.

SYSTEM COSTS

Examination of cost on a functional basis is only a part of the total cost picture. Since the purpose of the water supply utility is to deliver water to its customers, it is important to present costs in such a way that they relate the delivery of water to a demand point within the distribution system. The functional categories, both operating and capital, will therefore be reaggregated and assigned to physical components of the water system. This section contains such an analysis of the water supply system's cost.

TABLE 80. FAIRFAX COUNTY WATER AUTHORITY LABOR COST ANALYSIS

Item	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
Total payroll ($)	338,111	447,765	541,529	708,289	1,191,623	1,401,918	1,623,016	2,039,253	2,405,568	2,696,576
Total hours on payroll	---	---	---	---	352,605	374,217	352,712	449,566	492,488	519,994
Revenue-producing water (mil gal)	1,779	2,199	2,428	3,950	14,866	16,020	17,049	17.699	18,504	19,232
Total payroll/mil gal RPW ($)	190.06	203.62	223.04	179.31	80.16	87.51	95.21	115.22	130.00	140.21
Total hours/mil gal RPW	---	---	---	---	23.72	23.36	20.69	25.40	26.69	27.04
Average cost/man hour ($)	---	---	---	---	3.38	3.75	4.60	4.54	4.88	5.19

TABLE 81. FAIRFAX COUNTY WATER AUTHORITY CAPITAL AND OPERATING COSTS

Item	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
Operating cost	$707,901	$884,487	$1,096,406	$1,345,317	$2,317,132	$2,890,859	$3,229,023	$3,456,438	$3,937,701	$4,432,271
Depreciation	234,464	234,464	240,982	912,326	1,583,865	1,583,865	1,583,865	1,583,865	1,583,865	1,586,914
Interest*	608,006	663,038	663,038	663,038	4,799,993	3,401,288	4,934,620	4,105,420	4,059,620	4,011,220
Total cost	1,550,371	1,781,989	2,000,426	2,920,681	8,700,990	7,876,012	9,747,508	9,145,723	9,581,186	10,030,405
Total unit cost ($/mil gal)	871.48	810.36	823.90	739.41	585.29	491.64	571.73	516.74	517.79	521.55

* Interest figures for 1964, 1965, 1966, 1967, and 1969 were taken from the Annual Report. Other years were taken from the Interest and Sinking Fund Report of December 31 for each year.

TABLE 82. FAIRFAX COUNTY WATER AUTHORITY CAPITAL VERSUS OPERATING EXPENSE RATIOS

Item	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
Operating expense ($)	707,901	884,487	1,096,406	1,345,317	2,317,132	2,890,859	3,229,023	3,456,438	3,937,701	4,432,271
Capital expense ($)	842,470	897,502	904,020	1,575,364	6,383,858	4,985,153	6,518,485	5,689,285	5,643,485	5,598,134
Interest	608.006	663,038	663,038	663,038	4,799,993	3,401,288	4,934,620	4,105,420	4,059,620	4,011,220
Total cost ($)	1,550,371	1,781,989	2,000,426	2,920,681	8,700,990	7,876,012	9,747,508	9,145,723	9,581,186	10,030,405
Operating expense as % of total	45.66	49.63	54.81	46.06	26.63	36.70	33.13	37.79	41.10	44.19
Capital expense as % of total	54.34	50.37	45.19	53.94	73.37	63.30	66.87	62.21	58.90	55.81

Locations of the Fairfax County Water Authority's facilities are shown in Figure 41.

To analyze the cost of water as it moves through acquisition to treatment to the customer, it is necessary to identify the capital and operating cost of each system component. Figure 42 is a schematic diagram of Figure 41 and shows the operating and capital costs for each of the system's major facilities. A linear assumption is made to allow unit cost ($/mil gal) to be added as water moves from one component of the system to another. For example, the cost of acquiring water from the Occoquan supply is $17.56/mil gal, and the cost of treating 1 mil gal of water is $61.54. The cost of pumping the water from the treatment plant into the distribution system and delivering it to Zone 1 is $24.95/mil gal. These costs added together make an incremental cost of $103.74/mil gal for water delivered to Zone 1. Incremental costs are shown in Table 83.

Added to the incremental costs are the distribution cost, the interest cost, and the support services cost. The distribution cost is calculated on the assumption that these unit costs are constant throughout the system; the total capital and operating cost for distribution is therefore divided by the number of gallons of RPW in the year under consideration, yielding a figure of $104.44/mil gal. The same approach is taken for interest and support services. When these are added together, a total unit cost/($/mil gal) for delivery to a given area results. For example, the total cost for delivering water to Zone 1 is $505.33/mil gal. Table 83 contains the metered consumption for each of the pressure areas and the estimated contribution for recovering the total cost.

Once these calculations are made and various cost zones are established, the costs versus charges can be examined. Tables 84 and 85 summarize the water consumption rates charged by the Fairfax County Water Authority.

Costs of water for the 10 largest consumers served by the Authority are shown in Table 86.

By dividing the mil gal used into the amount charged, it is possible to examine the actual unit charge ($/mil gal), as shown in the last column of Table 86.

Average unit cost for all water supplied during the most recent year studied is as follows:

	$/mil gal
Support services	88
Acquisition	35
Treatment	56
Distribution	134
Interest	209
Total	522